
STAFF PROPOSAL ON REACTIVE POWER PRIORITY SETTING OF SMART INVERTERS

CALIFORNIA PUBLIC UTILITIES COMMISSION

ENERGY DIVISION

GRID PLANNING AND RELIABILITY SECTION



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INTRODUCTION AND SUMMARY

The Energy Division of the California Public Utilities Commission (CPUC or the Commission) has prepared this Staff Proposal to consider how the California electric investor-owned utilities (IOUs)¹ should modify current Volt/Var settings in Electric Tariff Rule 21 (Rule 21) to enhance grid function and reduce potential distribution grid upgrade costs associated with increasing penetrations of distributed energy resources (DERs),² while maintaining safety and reliability. This Staff Proposal is being circulated to the Smart Inverter Working Group (SIWG) for informal comments to help inform the Commission on options and timing for modifying the settings of the Volt/Var function in smart inverters.

The primary conclusion of this Staff Proposal is to modify Rule 21 tariff language to incorporate reactive power priority and to require new generating facilities interconnecting under Rule 21 to comply with the modified language by January 1, 2018.

This Staff Proposal supports the Commission and the state's policies towards reducing the sources of climate change through the widespread adoption and growth of distributed energy resources.

BACKGROUND

The Commission initiated Rulemaking (R.) 11-09-011 on September 22, 2011 to review and, if necessary, revise the rules and regulations governing the interconnection of generation and storage facilities to the electric distribution systems of the investor-owned utilities. The IOUs' rules and regulations pertaining to the interconnection of generating facilities are set forth in Electric Tariff Rule 21. Generating resources interconnecting to the utility grid via Rule 21 that produce direct current (DC) power require an inverter to convert the DC from the generating resource to the voltage and frequency of the alternating current (AC) distribution system.

In early 2013, the Smart Inverter Working Group (SIWG) was formed to develop proposals to take advantage of the new, rapidly advancing technical capabilities of advanced inverters (a.k.a. "smart inverters"). The Volt/Var function, which varies reactive power to counteract voltage deviations, was developed as part of the Phase 1 autonomous functions.³ The SIWG Phase 1 recommendations for updating technical requirements for inverters were completed in February 2014. The SIWG specified that the main purpose of the Volt/Var function is to use DER systems to help maintain voltages within their normal ranges and that the function can be particularly important for DER systems that may impact the normal voltage range on a feeder. The SIWG report recommended the function use "available vars" (reactive power) – "available vars" was defined as the "consumption or production of reactive power that does not affect the real power output."⁴

¹ Pacific Gas and Electric Company (PG&E), Southern California Edison Company (SCE), and San Diego Gas & Electric Company (SDG&E)

² DERs refer to distributed generation resources, energy efficiency, energy storage, electric vehicles, and demand response technologies.

³ Autonomous functions refer to inverter functionalities which do not require communications and can be turned on and utilized without input from the utility or customer.

⁴ Smart Inverter Working Group (2014) Recommendations for Updating the Technical Requirements for Inverters in Distributed Energy Resources. Filed February 7, 2014.

On December 18, 2014, the Commission issued Decision (D.) 14-12-035 (the Decision),⁵ requiring the IOUs to submit tariff revisions incorporating the SIWG recommendations through advice letter filings on January 20, 2015, which were subsequently approved by the Commission. The term used in each of the IOU's Rule 21 Tariff was "available reactive power" without a definition. "Available reactive power" has been referred to as "real power priority" by several stakeholders while discussing the Volt/Var function in ongoing SIWG webinar meetings.

The Decision also established a mandatory implementation date of smart inverters to be the later of December 31, 2015 or 12 months after the date the Underwriters Laboratory (UL) approves the applicable standard, UL 1741 Supplemental A (SA).⁶ UL 1741 SA was approved on September 8, 2016 and the mandatory date consequently became September 8, 2017.

D.14-12-035 acknowledged the capability of smart inverters to detect voltage at their terminals⁷ and to react autonomously to mitigate abnormal conditions: to provide reactive power if the voltage is low; to increase real power output if the frequency is low.⁸ The Decision also recognized that if properly applied, smart inverters can improve the performance of the distribution grid and the network as a whole, or, conversely, if improperly applied, can present serious problems in terms of voltage control.⁹ Consequently, the Commission requested that the utilities investigate the detailed specifications of the Volt/Var function and make a proposal one year after the adoption of the revised Electric Tariff Rule 21 as to the details of the function based on additional information and experience gained.¹⁰ At this time, no proposal from the IOUs has been submitted. However, the Volt/Var function power priority topic has been well discussed in SIWG meetings.

In lieu of waiting for an IOU proposal,¹¹ Staff offers this Staff Proposal to solicit informal stakeholder comments to the IOUs moving forward with changing detailed specifications of the Volt/Var function.

BENEFITS OF REACTIVE POWER PRIORITY

Recent research has indicated that the Volt/Var function may have a significant positive impact on mitigating DER grid integration costs. With this in mind, power priority is a fundamental element in the effectiveness of the Volt/Var function and smart inverters overall. Real power priority and reactive power priority are characterized as follows:

⁵ Interim Decision Adopting Revisions to Electric Tariff Rule 21 for Pacific Gas and Electric Company, Southern California Edison Company, and San Diego Gas & Electric Company to Require "Smart" Inverters. December 18, 2014.

⁶ D.14-12-035, Ordering Paragraph (OP) 4.

⁷ Terminal refers to interface of the inverter which connects to an electrical circuit.

⁸ *Id.* at 3.

⁹ *Id.* at 3

¹⁰ *Id.* OP 5.

¹¹ The IOUs interpret the proposal pursuant to D.14-12-035 to be required to be submitted on September 8, 2018, which is one year after the mandatory date of Phase 1 functions.

In situations where an inverter must make a choice between providing solely real power and curtailing some real power to provide/consume reactive power,

- *Inverters set to real power priority provide solely real power, and*
- *Inverters set to reactive power priority curtail some real power to provide/consume reactive power.*

Research has informed Commission Staff that when the capacity of the inverter has not been reached, there is no need to set a power priority, as the inverter does not have to reduce real power in order to provide/consume reactive power and regulate voltage. Thus, inverters may be sized larger to avoid the need to set power priority even when maximum generation output has been reached.

Additionally, research has shown that the Volt/Var function can improve voltage-related concerns and enable higher penetrations of DERs.¹² The same research also illustrated that different settings can significantly influence the effectiveness of the function. A recent draft DNV-GL study commissioned by the CPUC has indicated that smart inverters with reactive power priority may have a significant reduction in the grid integration costs of higher penetrations of PV.¹³

It is acknowledge that generators may experience a loss in real power with reactive power priority. However, the amount of reduction is limited by the infrequency of circumstances which would entail real power loss, i.e. peak real power output when load is minimal and there is a sufficient voltage excursion which requires reactive power from the inverter. Furthermore, the amount of real power loss during these limited times is restricted by the range of power factor.¹⁴ Therefore, it is expected that reactive power priority will result in a negligible loss in real power in the majority of cases. In addition, generators can expect no impact on real power if they size their inverters to avoid loss altogether.

Finally, the grid upgrade costs that can potentially be mitigated by a change to reactive power priority are far in excess of the expected costs associated with the loss of real power. The grid impact costs of NEM-eligible systems less than 1 MW are currently socialized among all ratepayers per current NEM 2.0 policy. However, this benefit to NEM customers is subject to review by the Commission in the 2019 NEM revisit planned in D.16-01-044. Hypothetically, if future NEM policy were to require some or all grid upgrade costs of NEM systems to be borne by participant NEM customers, then NEM customers would have a self-interest to use reactive power priority or size their smart inverters larger.

¹² Rylander, M. et al. (2013) DOE/VT/EPRI Hi-Pen PV Project, Phase III: Smart Inverter Modeling Results, Variability Analysis, and Hosting Capacity Beyond Thresholds. Electric Power Research Institute (EPRI).

¹³ Flinn, J. and Webber, C. (2017) Residential Zero Net Energy Building Integration Cost Analysis. DNV GL. Commissioned by the California Public Utilities Commission.

¹⁴ The IOUs submitted advice letters which modify Rule 21 to incorporate Smart Inverter Phase 1 clarifications and modifications on June 27, 2017 (SCE) and June, 2017 (PG&E and SDG&E) respectively. The proposed range of power factors is +/-0.95, which corresponds to a maximum loss in real power of 5% for the circumstances of which reactive power is needed.

JURISDICTIONS AND STANDARDS WITH REACTIVE POWER PRIORITY

In the latest revision of the Institute of Electrical and Electronic Engineers (IEEE) 1547 standard,¹⁵ stakeholders around the nation have agreed upon reactive power priority as the default setting for the Volt/Var function.

Furthermore, jurisdictions in Hawaii¹⁶ and Europe¹⁷ have instituted reactive power priority.

Staff believes the Commission should consider optimizing smart inverter settings to fully realize the SIWG's objective for the Volt/Var function – to help maintain voltages within their normal ranges.

STAFF PROPOSAL

CPUC Staff proposes to modify existing Rule 21 tariff language to incorporate reactive power priority through the following text change to Section Hh.2.j.

The Smart Inverter shall be capable of operating dynamically within a power factor range of +/- 0.85 PF for larger (>15 kW) systems, down to 20% of rated power, and +/- 0.9 PF for smaller systems (≤15 kW), down to 20% of rated power, ~~based on available reactive power~~. This dynamic volt/var capability shall be able to be activated or deactivated in accordance with Distribution Provider requirements.

When activated, the Smart Inverter shall provide reactive power irrespective of the effect on active power. ~~The reactive power provided shall be based on available reactive power, but the maximum reactive power provided to the system shall be as directed by the Distribution Provider.~~

Distribution Provider refers to the electric utility the customer is connected to, i.e. Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E), or Southern California Edison (SCE).

CPUC Staff proposes that new interconnecting generating facilities be required to comply with the modified language by January 1, 2018.

Staff envisions several possible procedural vehicles to effectuate this proposal, once informal stakeholder comment is received. First, if there appears to be consensus or most stakeholders support this change, the IOUs may submit advice letters to effectuate this Staff Proposal as pursuant to D.14-12-035's requirement of an IOU proposal on the detailed specifications of the Volt/Var function. Any interested entity could comment or file protests on such advice letters once filed. Second, if there

¹⁵ IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces.

¹⁶ See Hawaiian Electric Companies Grid Support Utility-Interactive Advanced Inverter Standards Source Requirements Document for Certification with Underwriters Laboratories 1741 Supplement SA.

¹⁷ See CLC/TS 50549-1:2015 Requirements for generating plants to be connected in parallel with distribution networks – Part 1: Connection to a LV distribution network above 16 A, a European Union technical specification.

appears to be significant controversy or a strong lack of technical consensus, Staff may recommend elevating this issue to a formal proceeding, such as the new Rule 21 interconnection proceeding.¹⁸

GUIDELINES FOR FEEDBACK

CPUC Staff request stakeholders address the following prompts:

1. Do you agree that transitioning to reactive power priority will better support voltage regulation and help to reduce distribution upgrade costs associated with high penetrations of DERs, and if so, why? Parties should offer the pros and cons of adopting reactive power priority.
2. Does the proposed tariff language adequately reflect the goal of the text change, i.e. to ensure reactive power priority, and if not, how can the text be modified?
3. Is the proposed date optimal and achievable, and if not, what is the preferred date and why? Please be specific in your reasoning. For instance, you may indicate what tasks and lengths of time are necessary to comply.
4. If the change to reactive power should not be adopted, please give specific reasons why not. Parties may provide any research and/or evidence available to demonstrate from a technical standpoint that real power priority should be kept in favor over transitioning to reactive power priority.

INSTRUCTIONS FOR SUBMITTING INFORMAL WRITTEN COMMENTS

To submit comments, please send but do not serve comments to Jeffrey Kwan (Jeffrey.Kwan@cpuc.ca.gov) of the Energy Division. It is not necessary to submit hard copies or to include certificates of service. Jeff will post submitted comments to the CPUC's Smart Inverter Working Group [webpage](#). All comments received by 5 PM on August 11, 2017 will be fully considered and posted. Jeff will send notification of the available comments once they are posted.

¹⁸ R.17-07-007.